Carbon Dreaming:
getting to know hummers, tropical leaves and power plants

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1962

KHRUSHCHEV ORDERS REMOVAL OF MISSILES

Vows Move In Note to President

[Map showing distances from various US cities to Havana, Cuba]
\[
\frac{\partial}{\partial t}(\rho C) = -\nabla \cdot (\rho C\vec{V}) + S_c
\]

........googoo!
The Global Carbon Cycle (pre-industrial)

Units: billion tons of C = 1 Gt C

Atmosphere: 500
- ~90 /yr
- ~120 /yr

Ocean: 38,000
- ~90 /yr

Land: 2000
- ~120 /yr

Rock: 10000000
The Global Carbon Cycle

Atmosphere
- 360 Gt C
- +4 Gt C/yr
- ~90 Gt C/yr
- +2 Gt C/yr

Ocean
- 38,000 Gt C
- ~90 Gt C/yr

Land
- 2000 Gt C
- ~120 Gt C/yr
- +3 Gt C/yr

Humans
- ~9 Gt C/yr
- 1.7 Gt C/yr
- 7 Gt C/yr
- +2 Gt C/yr

Units: billion tons of C = 1 Gt C

“Missing” carbon is hard to find!
Atmospheric CO₂ Inversions

Conceptually simple, practically hard problem

A hybrid of atmospheric transport and ecosystem science

Towards robust regional estimates of CO₂ sources and sinks using atmospheric transport models


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Information about regional carbon sources and sinks can be derived from variations in observed atmospheric CO₂ concentrations via inverse modelling with atmospheric tracer transport models. A consensus has not yet been reached regarding the size and distribution of regional carbon fluxes obtained using this approach, partly owing to the use of several different atmospheric transport models. Here we report estimates of surface-atmosphere CO₂ fluxes from an intercomparison of atmospheric CO₂ inversion models (the TransCom 3 project), which includes 16 transport models and model variants. We find an uptake of CO₂...
Sensitivity of atmospheric CO₂ inversions to seasonal and interannual variations in fossil fuel emissions

Kevin Robert Gurney,¹ Yu-Han Chen,² Takashi Maki,³ S. Randy Kawa,⁴ Arlyn Andrews,⁵ and Zhengxin Zhu⁶

Very sensitive!!
Kyoto Protocol
OCO (Orbital Carbon Observatory)

splash!...

but there is GOSAT OCO-2 coming next year
What have we been using?

1 degree resolution
Sales, consumption at national level with pop for proxy spatial
Roman
God of Fire
Real visualization scientist
..... in socioeconomics

“conservative, poor areas have higher per-capita carbon emissions than liberal, wealthier areas.

.....Representatives from such areas are shown to have much lower probabilities of voting in favor of greenhouse gas emissions reduction legislation”

Cragg, Gurney, Zhou & Kahn, Journal of Economic Inquiry, 2012

..... in energy analysis

Parshall, Gurney, Hammer et al. Energy Policy, 2009
Real economist!
Hestia

Greek goddess of the hearth and fire
Real urban planner
Hestia movie

Hourly CO$_2$ Emissions

Now doing Los Angeles and Phoenix!!
Thank you Scott Denning

Thank you Atmospheric Science

For seeing that the atmosphere is not just about the atmosphere!
Seasonal CO$_2$ Emissions

Thanks to Bedrich Benes, Michel Abdul, and Igor Razlivanov
Implications for inverse problem.....

"Error in the fossil fuel flux are directly aliased into estimate of biosphere exchange"

Gurney et al., Env. Sci & Tech., 2009
Corbin, et al., GRL, 2010
Schuh et al., Biogeosci. Disc., 2010
One person’s high-res is another’s low-res

Vulcan is the wrong data product for point measurements or urban scale comparisons......

All information is spread into a 10 km grid cell.
Hestia Overview – BUILDING/ROAD SEGMENT ESTIMATION

All point sources: Vulcan

All nonpoint buildings: thermo "skin" model

Transport: Vulcan with local MPO traffic and fleet

Aircraft, nonroad: Vulcan

Cement: Vulcan
1962

YEAR: 1960
PRICE: $0.10 - $0.15

YEAR: 2011
TALL CUP OF STARBUCKS:
$1.40 - $1.65
But first.........

Set some context for the birth of the Department of Atmospheric Science 50 years ago:

1962